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Abstract. The comfort of clothing is essential as to performance relative to the wearer and is considered a quality factor in the choice of a particular garment. That is why the science of comfort is used to evaluate jeans, a symbol of popular fashion and the consumption of the poor classes of Brazil [1]. Therefore, the present paper consists of the presentation of the experimental phase of a PhD research on the study of the comfort of Brazilian female jeans, specifically referring to thermal comfort tests through the use of equipment such as Permetest and Thermal Manikin for measuring thermophysiological comfort properties.

1. Introduction

The popular jeans in question refers to jeans created, produced and consumed by the popular poor class of the Northeast region of Brazil, with the main focus being the items sold at fairs and popular markets in Fortaleza, Ceará state, where fashion popular jeans have stood out due to economic incomes, job creation and income for the poor populations of the peripheral and rural urban areas of the cities of Ceará [2].

The aim of this research is to compare five different models of jeans used by consumers in order to carry out an analysis of the products offered in popular markets, taking into account thermo-physiological aspects, such as air permeability, thermal resistance and moisture behavior, in order to establish an understanding of the comfort characteristics that the female target population using this specific product choose.

The relevance of this research lies in the analysis of this type of jeans that are being offered in the popular markets, determining the most demanded jeans regarding comfort conditions in the scope of combine the study of science of comfort and fashion concepts in the Brazilian popular fashion market and even worldwide.

2. Materials and methods

The study is based on the methodology of ISO 11092: 2014 [3]. The methodology of evaluation of the physiological evaluation of clothing is organized in five levels. For this stage of research, we applied the techniques level 1, the physical-mechanical analysis of the materials (using testing equipment) and level 2, the biophysical analysis of the garment (using thermal manikin). Five models of female's jeans were purchased in the popular shopping centers of Fortaleza, Buraco da Gia and Beco da Poeira in Forteleza/Brazil.

In order to analyse the thermal properties of these fabrics, the relative water vapour permeability (RWVP) and the absolute water vapour permeability (AWVP) were measured using PERMETEST[4], and the air permeability was measured on a Textest FX 3300 instrument [5] and the measurement of thermal insulation with the use of Thermal Manikin[6] Maria of the University of Minho PT-Teknik made in Denmark, in a thermal chamber with controlled environment with temperature and humidity between 28ºC with a variation of ± 2ºC and 65%, with variation of ± 2%. The thermal resistance tests

were performed at 37ºC corresponding to the internal temperature of the human body.

The data were analysed statistically using Excel and SPSS software version 23 (Statistical Package for the Social Sciences), using the SPSS in ANOVA analysis of variance, applying the later tests, Tukey tests, with significance level of 0.05.

3. Results

The Popular jeans were initially analysed for fabric composition, structure, count threats and industrial washing types are presented in table 1.

Table 1. Jeans description

Jeans Models	Jeans 1	Jeans 2	Jeans 3	Jeans 4	Jeans 5
Image					
Composition	98%contton 2%spandex	77%contton 21%polyester 2% spandex	98%contton 2% spandex	96,5%contton 3,5% spandex	77%contton 21%polyester 2% spandex
Industrial wash	Acid wash and destroyed - hand scraping	Stone wash and acid wash (permanganate)	Dark water jet wash and overall crinkle (resin)	Dark sulfur dyeing	Rinse wash and softener
Structure	Twill (2/1 1)	Twill (2/1 1)	Twill (3/1 1)	Twill (3/1 1)	Twill (3/1 1)
Count threats (yarns/cm)	29 x 21	37 x 23	39 x 22	40 x 26	38 x 23

After that, the results of the ANOVA variance analysis were calculated using the models of jeans and thus comparing the values of the characterization measurements materials and of the data of the jeans thermophysiological tests. With the test of homogeneity of variances, the Levene test has as hypothesis H0 that there is homogeneity of variances between the different treatments, when analysing the data, it was observed the existence of both homogeneity and heterogeneity between the averages of the treatments performed. To better emphasize the relationship between the different jeans as the physical characteristics the analysis of multiple comparisons of the means was done through the Tukey test. The comparison of the means in homogeneous subsets, with harmonic mean = 10,000.

The analysis of the comparison of the measures means of the mass per unit area are expressed in table 2 and the comparison of the homogeneous groups are shown in figure 1.

Table 2. Mass/unit area (g/m^2)

Tukey HSD[a]	**Mass/unit area (g/m^2)**		
Models	Subset for alpha= 0.05		
	1	2	3
Jeans 1	281,43		
Jeans 4	289,08		
Jeans 3		321,93	
Jeans 5		323,52	
Jeans 2			332,08
Sig.	0,052	0,976	1,000

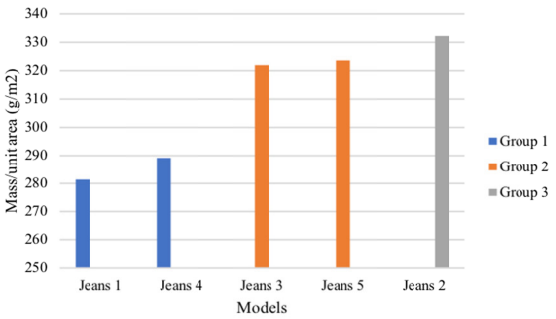

Figure 1. mass/unit area(g/m^2) homogeneous groups

Evaluating the mass/unit area values of the 5 jeans models, group 1- jeans 1 and jeans 4 had lower mass values, although jeans 4 presented 7.65 (g/m^2) higher than jeans 1, they are considered statistically homogeneous the value of significance = 0.052. Group 2 - jeans 3 and jeans 5 are also evaluated as homogeneous with significance = 0.976, when purchased with the other jeans showed values of mass greater than group 1 and smaller than group 3. Group 3 - jeans 2 presents higher mass/unit area (g/m^2).

The analysis of the comparison of the averages as the thickness measures are expressed in table 3, the data shown in figure 2.

Table 3. Thickness(mm)

Tukey HSD[a]	**Thickness (mm)**			
	Subset for alpha= 0.05			
Models	1	2	3	4
Jeans 1	,6970			
Jeans 4		,7170		
Jeans 3			,7490	
Jeans 5			,7530	
Jeans 2				,8340
Sig.	1,000	1,000	,973	1,000

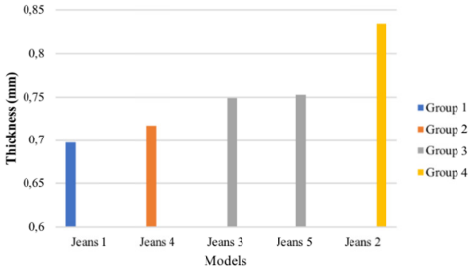

Figure 2. Thickness(mm) homogeneous groups

Evaluating the comparison of the fabric thickness values, the group 1 - jeans 1 0.6970 mm, smaller value; group 2 - jeans 4, 0.7170 mm; group 3 - jeans 3 and 5 are also evaluated as homogeneous with significance = 0.973; and group 4 - jeans 2 .0,8340 mm, with bigger value.

The comparison of the means data of the tests thermophysiological properties analysis as air permeability, relative water vapour permeability (RWVP) and absolute water vapour permeability (AWVP) are evaluated in homogeneous subsets, with harmonic mean = 10,000.

The analysis of the means measurements air permeability are shown in table 4, with the data shown in figure 3.

Table 4 - Air Pemeability (l/m^2/s)

Tukey HSD[a]	**Air Pemeability (l/m^2/s)**	
	Subset for alpha = 0.05	
Models	1	2
Jeans 5	37,19	
Jeans 1	38,23	
Jeans 2		48,69
Jeans 4		49,62
Jeans 3		49,89
Sig.	,897	,838

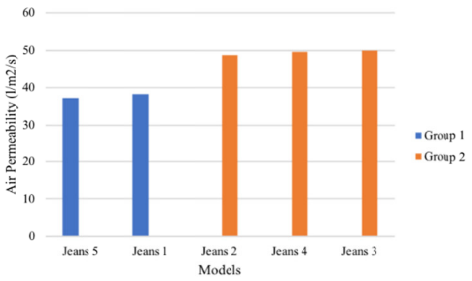

Figure 3. Air Pemeability (l/m^2/s) homogeneous groups

Comparing the air permeability values, we observed homogeneity of the values divided into two groups: group 1, with lower values - jeans 5 (37,19 l/m^2/s) and jeans 1 (38,23 l/m^2/s) and group 2: jeans 2 (48.69 l/m^2/s), jeans 4 (49.62 l/m^2/s) and jeans 3 (49.89 l/m^2/s), the latter showing higher air permeability value.

The analysis of the relative water vapor permeability values are shown in table 5, with the data shown in figure 4.

Table 5. Relative Water Vapour Permeability (RWVP) (%)

Tukey HSD[a]	**Relative Water Vapour Permeability (RWVP) (%)** Subset for alpha= 0.05			
Models	1	2	3	4
Jeans 2	56,28			
Jeans 1		60		
Jeans 5		61,66	61,66	
Jeans 3			63,76	
Jeans 4				68,98
Sig.	1,000	,434	,209	1,000

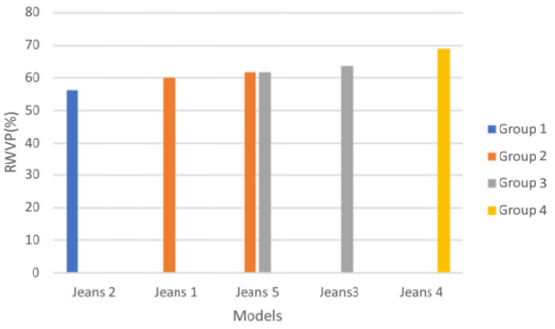

Figure 4. Relative Water Vapour Permeability (RWVP) (%) homogeneous groups

Evaluating the comparison of the relative water vapor permeability values, homogeneity was observed in 4 different groups. Group 1 - jeans 2 (56.28%) with lower value; group 2 - jeans 1 (60%) and jeans 5 (61.66%), jeans 5 also belonging to group 3 due to being statistically very close to jeans 3 (63.76%) and group 4 - jeans 4 (68.98%) with higher relative water vapor permeability value.

The analysis of the relative water vapor permeability values are shown in table 6, with the data shown in figure 4.

Table 6. Absolute Water Vapour Permeability (RWVP) ($Pa/m^2/W^{-1}$)

Tukey HSD[a]	**Absolute Water Vapour Permeability (RWVP)** ($Pa/m^2/W^{-1}$) Subset for alpha= 0.05		
Models	1	2	3
Jeans 4	3,3		
Jeans 3		4,0	
Jeans 5		4,4	
Jeans 1			5,5
Jeans 2			5,5
Sig.	1,000	,271	1,000

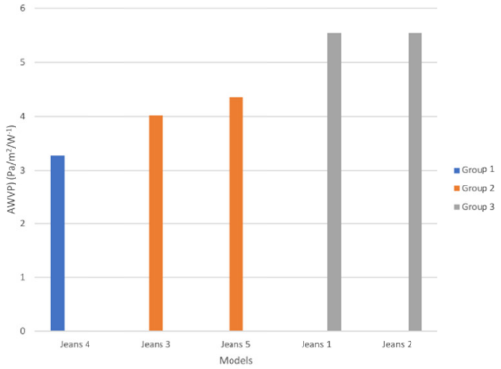

Figure 5. Absolute Water Vapour Permeability (RWVP) ($Pa/m^2/W^{-1}$) homogeneous groups

Evaluating the comparison of the absolute water vapour permeability values, homogeneity is observed in 3 different groups. Group 1 - jeans 4 (3,3 Pa / m^2 / W^{-1}) with lower value; group 2 - jeans 3 (4,0 Pa / m^2 / W^{-1}) and jeans 5 (4,4 Pa / m^2 / W^{-1}) the group 3 - jeans 1 and jeans 2 equal values (5,5 Pa / m^2 / W^{-1})) with bigger value of absolute water vapor permeability.

The analysis of the comparison of the heat loss values referring to the different parts of the body are expressed in figure 4.

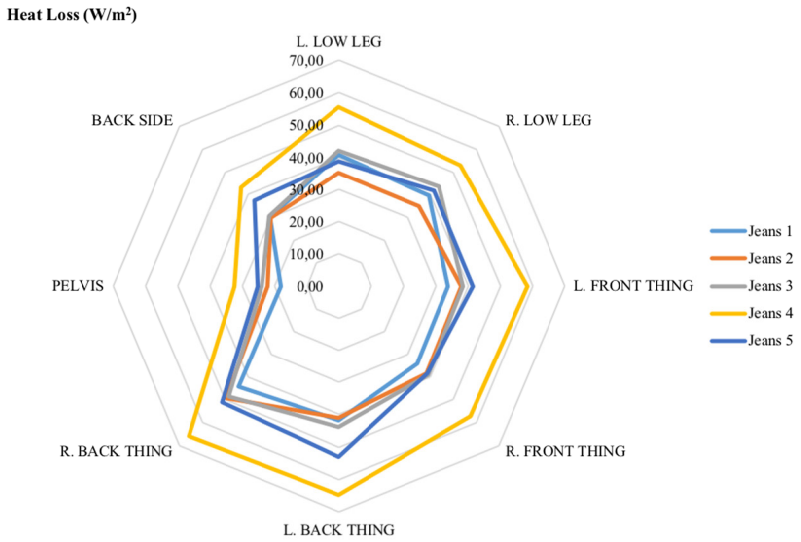

Figure 6. Heat loss from body section of manikin dressed with five jeans models

Evaluating the comparison of the heat loss values, we can observe values homogeneity, with lower values of heat loss - jeans 1, jeans 2 and jeans 3, being the order from the lowest to the highest, then jeans 5 and finally the jeans 4 standing out with greater value of loss of heat in all parts of the body.

The analysis of the comparison of the total *(It)* and effective *(Icle)* thermal insulation values of each jeans model are expressed in figure 5.

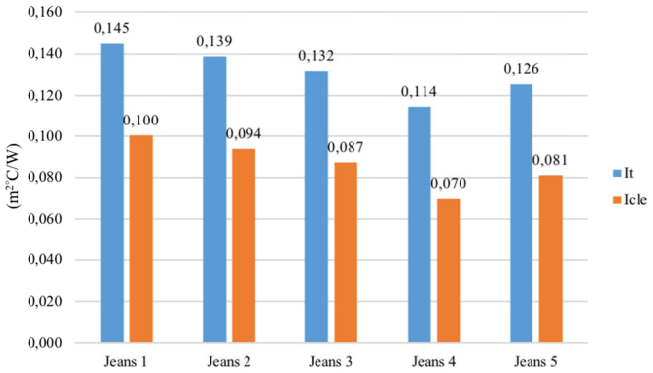

Figure 7. Total thermal insulation and effective clothing insulation of five jeans models

In the comparison of the total and effective insulation values, it is observed that jeans 1 *It* (0,145 m^2.°C/W) and *Icle* (0,100 m^2.°C/W), jeans 2 *It* (0,139 m^2.°C/W) and *Icle* (0,094 m^2.°C/W), and jeans 3 *It* (0,132 m^2.°C/W) and *Icle* (0.087 m^2.°C/W) this tree models presented the highest values for total thermal insulation *It*, and also effective thermal insulation *Icle*. Following in descending order, jeans 5 with *It* (0,126) and *Icle* (0,081 m^2.°C/W) and jeans 4 *It* (0,114 m^2.°C/W) and *Icle* (0,070 m^2.°C/W) are presented, showing the lowest total and effective thermal insulation values.

4. Conclusions

Through the evaluations of the parameters described above it is possible to highlight the following conclusions:

• The jeans 1, although presenting lower values of mass and thickness and low capacity of air permeability. The jeans 1 presents the second lowest value of relative water vapor permeability and the highest absolute permeability value to water vapor and higher values of total thermal insulation *It* and effective *Icle.*

• Jeans 2 presented higher values of mass and thickness, the air permeability presented higher value

than jeans 1. Jeans 2 presents lower value of relative water vapor permeability and as for the value of absolute permeability water vapour jeans 2 presents values equal to jeans 1 with greater permeability to absolute water vapor. When analysed the values for heat loss and total thermal insulation and presented data close to the values of jeans 1.

• Jeans 3 and jeans 5 presented statistically equal values for the mass and thickness of the fabrics. The jeans 3 and jeans 5 present statistically very close values regarding the relative water vapor permeability value and absolute water vapor permeability. The heat loss and total and effective thermal insulation. higher value and jeans 5 the lowest value.

• The jeans 4 for the values of mass and thickness presented low values, slightly larger than the jeans 1 and smaller values when compared with the other models. The air permeability values, presented the second lower value, with data similar to jeans 2. The jeans 4 presented highest relative water vapor permeability value and the lowest absolute water vapor permeability value. It stood out with higher values of heat loss in all parts of the body and when compared to all models of jeans. It presented lower value of total and effective thermal insulation, when comparing the values with the other models.

The results show that the raw material, the structures, the construction of the fabrics, as well as the type of industrial washing influence the thermophysiological properties of the different tested models of jeans. It was possible to conclude that the objective evaluation of the comfort of popular clothing and specifically of jeans designed, produced and sold in Brazilian popular markets is unprecedented and that there is much to research, study and to learn from the popular fashion universe of the Brazilian Northeast.

Future perspectives

In further studies we will compare the results obtained through objective evaluation with data obtained through evaluation using a inquiry and scales. This study is also important for the producers and traders of Fortaleza of this type of product in order to contribute to the development of this huge market.

Acknowledgments

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